NUI Galway
OÉ Gaillimh

Autumn Examinations 2021-2022

Exam Code(s)	4BCT, 3BP, 4BP
Exam(s)	Fourth Year Computer Science and Information Technology Third and Fourth Year Electronic and Computer Engineering
Module Code(s)	CT414
Module(s)	Distributed Systems
Paper No.	1
External Examiner(s)	Dr. R. Trestian
Internal Examiner(s)	Prof. M. Madden *Dr. D. Chambers

Instructions: Answer any 4 out of the 5 questions.
All questions carry equal marks.

Duration	2 hrs
No. of Pages	4
Department(s)	School of Computer Science

Requirements:

Release in Exam Venue	Yes	X	No	
MCQ Answersheet	Yes		No	X
Handout	None			
Statistical / Log Tables	None			
Cambridge Tables	None			
Graph Paper	None			
Log Graph Paper	None			
Other Materials	None			
Graphic material in colour	Yes		No	X

Question 1

Using Java Remote Method Invocation, outline the design for an Internet based automated assessment system for the university. The server allows users to authenticate themselves and download an assessment object. The system uses an interface that provides methods to retrieve and answer a list of multiple-choice questions. The (updated) assessment object can then be submitted back to the server for verification and correction. The design of the system should make it possible for new Assessment implementation classes to be easily added to the server in the future, making the system very flexible.

The design should use Java RMI and Object Serialisation to download and then submit objects that implement the Assessment interface i.e. these objects are passed by value from the server to the client and then back again to the server. Full implementation classes (for *ExamServer* and *Assessment*) are not required but the answer should include full source code for the Java interfaces and mainline client and server code as described below:

- *ExamServer* - this remote interface should provide methods for user authentication, download of assessments and the submission of completed assessments. Assessments can only be downloaded and submitted during certain specified time intervals. Include definitions for any exceptions that may be required in method definitions. 7 MARKS

- *Assessment* - this serializable interface should provide methods for the retrieval of information about the assessment, and the retrieval / answering of questions. It should also have a method to output the selected answer to each question - the answer provided to a question can then be changed, if desired, prior to submission of the assessment. 8 MARKS

- Provide the mainline server code required to fully initialise the server and then register an instance of the *ExamServer* implementation class in the RMI Registry. 5 MARKS

- Provide a simple client program that can use or interact with the server i.e. it downloads an assessment object, completes the assessment and then submits the assessment object back to the server. 5 MARKS

Question 2

a: What is *message oriented middleware* and what types of messaging models are available in the Java Messaging Service? 5 MARKS

b: You have been asked to design an application that allows weather updates on specific areas to be retrieved from a central web server and then forwarded periodically to interested client applications. Describe a suitable architecture and design for a distributed application that uses the Java Messaging Service (JMS) to handle the distribution of the weather update messages. Full Java source code is not required but your answer should provide a full description of how the JMS could be used within the application. Also describe how the application might use the Java Naming and Directory Interface (JNDI) as part of this solution. 10 MARKS

c: Assume that you have been contracted by a large multinational company to develop an enterprise class client / server application that may be accessed by a large number of clients concurrently. You will therefore need to employ some form of load balancing in the design of the application. What type of load balancing systems would you recommend? In this context, include both low level load balancing algorithms and high level load balancing mechanisms such as round-robin DNS and IP Anycast using BGP. Provide some real world examples of systems or services that use DNS and IP Anycast. 10 MARKS

Question 3

a: Explain the role of the Proxmox Virtualisation Environment. In this context, what is the difference between a Virtual Machine and a Container? 6 MARKS

b: How is it possible to run Virtual Machines at near native speed using Kernel-based Virtual Machine (KVM) infrastructure? 4 MARKS

c: What is the purpose of the Ceph storage platform and what advantages does it have over traditional RAID based storage? Describe the high level architecture and the main components of the Ceph storage platform. Include in this description details about the following items: Ceph Network, Object Storage Devices and Ceph Pools. 8 MARKS

d: What are the advantages of grouping physical servers into a cluster? How does a Proxmox cluster implement High Availability and what might cause a Virtual Machine migration to fail? 7 MARKS

Question 4

a: Describe briefly the advantages of using the EJB component framework in the context of high volume distributed object applications. What types of beans may be defined using the EJB framework? 5 MARKS

b: Suppose you work for a social media company that collects a lot of very large data sets e.g. web logs or other application related data that needs to be stored and analysed. Also assume that the company has access to large scale computing resources based in multiple data centres. Explain how using the Apache Hadoop Distributed File System and its related facilities might help in solving the storage and analysis requirements of the company. Discuss the advantages of this approach over using traditional database systems for this type of data. 8 MARKS

c: Describe in detail the MapReduce programming model. Outline the architecture for a MapReduce application that could be used to index a large number of text files by the individual words present in each file. Full source code for the application is not required but your answer should include the data structures that could be used and also clearly explain the purpose and functionality of the map() and reduce() functions in solving this problem. 12 MARKS

Question 5

a: What kind of applications can use Node.js? What is unique about Node.js when compared to other server technologies like e.g. the Apache web server? 4 MARKS

b: Explain briefly the purpose of the **npm** utility. Describe exactly the purpose and the effect of running the following command:

npm install ejs -g 5 MARKS

c: In the context of implementing a web server type application in Node.js what are the advantages of using the **Express** framework? Write the Node.js code to implement a simple web server, using the Express framework, that responds with a simple text message when the URI /**main** is invoked. 7 MARKS

d: You have been asked to develop a web based Todo list application using Node.js and related technologies and the architecture should follow a Model-View-Controller type approach. Based on these requirements, describe a suitable top-level application architecture. Identify the technologies and additional Node.js modules that will be used and explain the role each of these technologies plays in the overall system architecture. 9 MARKS